Original Article

Comparative evaluation of different osteosynthesis modalities with respect to lingual splaying in mandibular interforaminal fractures using CBCT: A prospective study

ABSTRACT

Introduction: The management of interforaminal fracture can prove to be challenging because of its unique anatomy and muscular forces. Often, lingual splaying has been found either postoperatively or even during the procedures in such fractures and can be challenging when it comes to managing them. Various modalities such as miniplates, lag screws, and three-dimensional (3D) miniplates have been utilized to manage these fractures. This article compares these three modalities in the management of lingual splaying.

Material and Methods: Thirty patients were allotted randomly to either of the aforementioned modalities randomly in this prospective study. The patients were operated and followed up for the period of 6 months.

Results: It was found that no significant difference exists between the modalities in terms of reduction in lingual splay.

Conclusion: All three modalities have different ventures to offer. A larger sample size study may be warranted to elucidate the obtained results.

Keywords: 3D plates, lag screws, lingual splay, miniplates

INTRODUCTION

The management of interforaminal fracture can prove to be challenging because of its unique anatomy and muscular forces. One complication that surgeons regularly encounter is achieving an adequate lingual reduction. The possible reason for such lingual splay can be an inadequate reduction or opening up of the lingual cortices during hardware fixation. It is challenging to identify and recognize such lingual discrepancy intraoperatively, and even a small splay can lead to a significant increase in bigonial width. Fractures in this area of the mandible predispose the patients to malocclusion and widening of the face if not properly treated.[1,2]

The lag screw technique was first described by Brons and Boering in 1970 who postulated that it not only immobilizes the fracture fragments but also produces a constant compression of the fracture area. It is a safe and effective method of rigid fixation. Besides supplying compression between the fragments to support healing, fracture stabilization is firm, and tissue exposure is reduced.[3,4] In 1973, Michelet introduced miniplates via a transoral approach and Champy further refined and researched miniplates. The approach to rigid plate fixation was then modified with progressively smaller plates and less reliance on compression.[5] Because of the torsional forces generated during function, two miniplates are advocated to predictably

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Received: 06 January 2023, **Revised:** 09 March 2023, **Accepted:** 22 May 2023, **Published:** 19 March 2024

Access this article online	
Website: www.njms.in	Quick Response Code
DOI: 10.4103/njms.njms_5_23	

How to cite this article: Mittal G, Garg R, Rathi A, Ghatak DP, Biswas J. Comparative evaluation of different osteosynthesis modalities with respect to lingual splaying in mandibular interforaminal fractures using CBCT: A prospective study. Natl J Maxillofac Surg 2024;15:100-5.

maintain rigid fixation during healing. They provide better handling, higher stability, and less pressure on the bone.[6] The shortcomings of rigid and semi-rigid fixation like led to the development of 3D miniplates, consisting of 2 × 4-hole miniplates joined by four interconnecting cross-struts. Farmand and Dupoirieux (1992) presented this system of plates made of titanium. Easy use, good resistance against torque, and compact form of the plate were some of the advantages.[7-9]

This study was conducted to evaluate the efficacy of various techniques of osteosynthesis with respect to lingual splaying in mandibular interforaminal fractures using cone-beam computed tomography (CBCT). The objective was to evaluate the efficacy of 3D miniplates, standard miniplates, and lag screw and to compare the aforementioned osteosynthesis modalities in terms of stability of fracture and lingual splaying.

MATERIAL AND METHODS

This study was carried out to compare and evaluate 3D plates, miniplates, and lag screws and find out which one was better in reducing postoperative lingual splay. All dentate patients of the age group of 20 to 60 years with confirmed clinical or radiographical interforaminal mandibular fractures reporting to the Department of Oral and Maxillofacial Surgery were included in this study. Patients with infected fractures, comminuted fracture, atrophic mandible, pathological fractures, and American Society of Anesthesiologists (ASA) III and IV criteria patients were excluded. The selected patients were then divided randomly into three groups: group A: 3D stainless steel miniplates (3D plates), group B: two stainless steel conventional miniplates, and group C: two stainless steel lag screws. Ethical clearence was obtained from Ethical committee with Ref no. IDST/IEC/2020-23/17 dated 18th January 2021.

Preoperative records such as radiographs such as orthopantomagram (OPG) and CBCT along with clinical pictures of the patients were prepared. All patients were operated under general anesthesia. An intraoral vestibular approach was used to expose the fracture site and was reduced followed by intermaxillary fixation to immobilize the reduced fragments. Fixation was done depending on which group the patient was allocated to, that is, 3D plates (a and b), miniplates (c and d), or lag screws (e and f) [Figure 1]. The intermaxillary fixation was then released, and occlusion was assessed on the table. The wound was closed, and the patient was extubated uneventfully and shifted for post-op care under the regime of standard medications.

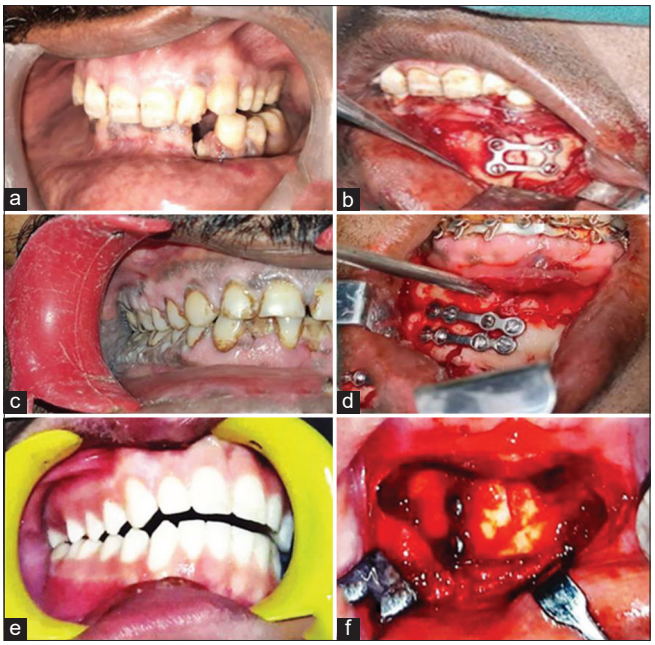


Figure 1: Pre-opertaive fracture sites various osteosynthesis modalities in place. (a) Right Parasymhysis #, (b) Right Parasymhysis # treated with 3-D plate, (c) Right parasymphysis fracture, (d) Right Parasymhysis # treated with convebntional miniplates, (e) Right Parasymhysis #, (f) Right Parasymhysis # treated with lag screws

Postoperative photographs were taken. Preoperative radiographs included OPG and CBCT. Postoperatively, these radiographs were also taken in the 1st week, 1st month, and 3rd month. The patients were assessed for lingual splay measurement and scoring, pain score according to the visual analog scale, occlusion discrepancy, stability of fracture fragments, need for postoperative maxillomandibular fixation (MMF), facial asymmetry, malunion of fragments, hardware failure, paresthesia, infection or swelling, plate removal operating time, and bite force.

RESULTS

Our study comprised a total of 30 patients of whom 22 were males (73.3%) and eight were females (26.7%). Patients were 18 to 70 years of age group with a mean age of 34.87 ± 12.091 years.

Road traffic accident was the most common cause of trauma, which accounted for 60% of cases followed by fall, which was 40% of cases.

Preoperatively, the mean lingual splay measurement was 1.805 ± 0.81 mm in the 3D plate group, 2.04 ± 0.85 mm in the lag screw group, and 2.07 ± 0.55 mm in the miniplate group. After 1 week, it was 1.01 ± 0.63 mm in the 3D plate group, 1.06 ± 0.54 mm in the lag screw group, and

1.11 ± 0.28 mm in the miniplate group. After 1 month, the mean lingual splay was unchanged, and at the 3rd-month follow-up, there was no splaying in the 3D and miniplate group and negligible in the lag screw group, which was 0.04 ± 0.084 mm. The difference between the groups showed no statistical significance.

The method for assessment of lingual splay was followed according to Prasad *et al.*,[9] which required evaluation by the operating surgeon using CBCT taken preoperatively and postoperatively. In our study, six of 10 patients of the 3D plate group have +1 score, while four of them have 0 score; six of 10 of the miniplate group patients have +1 score, while 1 patient has 0 and -1 scores each; and six of 10 of the lag screw group patients have scored +1, while 4 of them have scored 0. The results show no statistical significance among the groups.

The pain was evaluated based on the visual analog scale (0–10). All patients complained of mild pain after surgery, which lasted for one week. No difference in statistical significance was found between the three study groups.

Occlusal discrepancy persisted in only two patients each from the 3D plate group and miniplate group till the 1st-week follow-up, which subsided in subsequent follow-ups. There is no statistically significant difference among the study groups.

90% of patients from each study group had displaced fracture preoperatively. Only 20% of patients from the miniplate group showed some displacement radiographically in the 1st-week follow-up, which subsided during the subsequent follow-ups. No statistically significant difference was seen among the groups.

All the patients required postoperative MMF for 1 week after surgery, which was removed by 1st-month follow-up except for two patients in the 3D plate group and two patients in the miniplate group in whom it was removed after 1st-month follow-up. There is no statistically significant difference among the study groups.

There was no incidence of hardware exposure or failure or removal after surgery during any of the follow-up periods in any of the patients.

20% and 10% of patients from the miniplate group and lag screw group, respectively, had an infection or swelling preoperatively. At the first-week follow-up, 10% of patients had the presence of infection or swelling in both groups, which subsided in subsequent follow-ups. This result was statistically nonsignificant.

In our study, nerve paresthesia existed in 10% of patients in the 3D plate group and the miniplate group preoperatively, which persisted for 1 week after surgery and subsided in the subsequent follow-ups. The result is statistically nonsignificant.

In our study, none of the patients showed any signs of nonunion or malunion of fracture fragments when assessed radiographically in the postoperative phase.

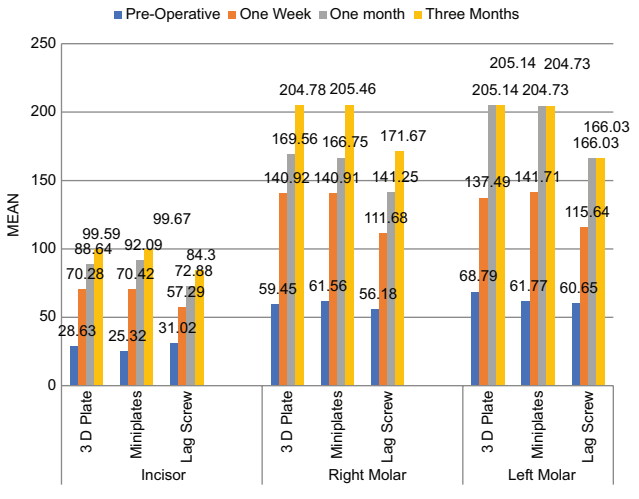
In our study, we found a significant statistical difference in the operating time of patients treated with lag screw having a mean operating time of 23.60 ± 2.17 minutes, patients treated with 3D plate having a mean operating time of 43.80 ± 3.25 minutes, and patients treated with miniplates having a mean operating time of 65.60 ± 5.33 minutes [Table 1].

The bite force measurement at the incisor, left molar, and right molar regions had increased progressively at each of the postoperative follow-up visits such as 1 week, 1 month, and 3rd month compared with the previously recorded preoperative value. The results show that the difference in the

Table 1: Comparison of operating time taken

Parameter	Modality	*n*	Mean	Std. deviation	One-way ANOVA	
					P	Significance
Operating time	3D plate	10	43.80	3.259	0.000	Significant
	Miniplates	10	65.60	5.337		
	Lag screw	10	23.60	2.171		
	Total	30	44.33	17.829		

Figure 2: Comparison of bite force throughout the study duration between the three osteosynthesis modalities



three regions in each of the follow-up visits was significantly better in the 3D plate and miniplate groups compared with the lag screw group [Figure 2].

DISCUSSION

The arduous pace of modern life with high-speed travel and an increasingly violent and dictatorial society has made trauma to maxillofacial complex one of the most important health problems worldwide. The mandible due to its prominent position is one of the most commonly fractured bone in the facial skeleton. It is a unique bone with a complex role in the esthetics of the face and functional occlusion. It has been reported that fractures of the mandible account for 36%–59% of all maxillofacial fractures. Fractures of the mandible cause both functional disabilities and social and cosmetic morbidities. The aim of mandibular fracture treatment is the restoration of anatomical form and function, with particular care to establish the occlusion and allow immediate return to the function.[10]

In the area of the mandibular symphysis, a small error in reduction can result in a large change in the position of the mandibular rami. When support for the mandibular symphysis is lost due to fractures of the condyle, angle, body, and/or symphysis, there is a tendency for the symphyseal region to move posteriorly and the rami to flare laterally due to the pull of the lingual musculature attached to the mandibular symphysis. Symphyseal fractures, especially those associated with condylar fracture and a poor dentition, are prone to facial widening. Even with an intact dentition, there is a tendency toward splaying of the gonial angles due to the application of the maxillomandibular wires on the buccal surface of the dentition, which causes the mandibular segments to tip lingually, even though the teeth appear properly interdigitated. In those symphyseal fractures treated by an open procedure, a gap in the line of fracture may be noted at the inferior border of the mandible even though the mandibular incisors are in approximation superiorly, which necessitates to loosen the wires slightly to obtain proper osseous reduction at the inferior border. A great amount of widening at the gonial angles can occur if the bones themselves are not inspected for approximation in cases of poor dentition. If the bone plate is not properly bent and/or overbent, the lingual cortices may not contact even though the buccal cortices appear perfectly reduced. In such cases, tightening the screws, especially if compression is applied, would cause the rami to move laterally. If the mandibular teeth are lingually inclined and upright to a more normal relationship with digital pressure at the gonial angles, open reduction in the symphyseal fracture must be considered. Post-op intermaxillary fixation, if applied, is most effective if placed bicortically so that the lingual cortices are also approximated by the wire.[11]

According to Bhargava *et al.,* the fracture fragments can be engaged in the reduced position using a lag screw of 12 to 14 mm after which the plates can then be adapted to the contour of the mandible. Fixation of all the screws is done as per Champy's principles, except for the screw passing through the inter-fragmentary screw path, which is removed before placement of the final screw. Thus, it is useful in ensuring the adequacy of lingual reduction and diminishing the chances of lingual splay due to errors in handling the reduction forceps besides reducing the chances of error incorporation in fracture reduction, while the fixation of the plate is carried out.[2,12]

Miniplates placed according to Champy's ideal lines should be placed within 10 mm of the superior border, but in the anterior part of the mandible, torsional and bending forces are greater and higher near the mandibular symphysis, which cause movement along the axis of the plate with buccolingual splaying and gap formation at the inferior border, respectively. So, it is advocated to overbend the plate as a way to get an accurate reduction of the lingual cortex and overcome the tendency of the fracture to remain splayed open, besides applying pressure at the gonial angles.

Jimson *et al.* studied and compared 3D plates and miniplates and found three times lesser number of patients with postoperative lingual splay than conventional miniplates. Ponvel *et al.* ascertained the correction of lingual splay during fixation of 3D miniplate in their study as it reduced stress distribution and negated the pressure related to resorption of bone, which may be clinically significant. Prasad *et al.* who placed 3D plates in 18 patients measured lingual splay of the fractured mandibles pre- and postoperatively using occlusal radiographs and found that 72.2% of them showed a significant reduction in lingual splay, 16.6% showed minimal or no change in lingual splay reduction, and 11.1% showed an increase in lingual splay.[2,9,13] Siddiqui *et al.* and more recently Mohammad *et al.* who both placed 3D and conventional plates in their studies did not find any postoperative lingual splay at any follow-up periods. Hatem *et al.* found similar results in their study using conventional miniplates where they measured the mesiodistal plane discrepancy in terms of the linear width of the inter-fragmentary gap and the linear depth of buccolingual gap in terms of lingual splay at the inferior border between the fractured mesial and proximal segments using CBCT.[14-16]

In this study, the lingual splay was measured in each of the cases preoperatively and postoperatively using CBCT. We

found that 60% of patients treated with 3D plates showed a significant reduction in lingual splay, 80% of patients treated with conventional miniplates showed a significant reduction in lingual splay, and 60% of patients treated with lag screws had significant reduction in lingual splay. The increase in lingual splay seen in one patient was attributed to the fact that the patient had a concurrent condylar fracture, which worsened the splay and hence the occlusion initially, but with the application of elastics for two weeks, it was observed that the malocclusion subsided and radiographically the splay had decreased by the first-month follow-up.

In this study, the mean intraoperative time for the lag screw group was least followed by the 3D group and the maximum time was taken in the miniplate group. There was a statistically significant difference among the groups, which was similar to studies conducted by Mittal *et al.*, Tiwari *et al.*, Kaushik *et al.,* and Mohammad *et al.*[15,17-19] Post-op intermaxillary fixation was required in all patients for one week and two patients each in the 3D plate group and the miniplate group for one month. This was in contrast to study by Balakrishnan *et al.*, Malhotra *et al.,* and Agnihotri *et al.* In the study by Sehgal *et al.,* 40% of the 3D plate group and 73% of patients of the miniplate group required post-op intermaxillary fixation.[20-23] Some occlusal discrepancies that were seen in this study stabilized within the first month of the follow-up period. The results were similar to the studies conducted by Mittal *et al.*, while Malhotra *et al.* found that 30% of patients of the miniplate group and 10% from the 3D group had a occlusal discrepancy with no statistical significance, which was similar to Barde *et al.*[24] A study by Prasad *et al.* who treated with 3D plates showed only 11.1% of patients with loss of occlusal stability, which was corrected with intermaxillary fixation. Studies by Elhussein *et al.* and Jambhulkar *et al.* showed no occlusal discrepancies at any follow-up periods.[3,25] Infection or swelling in this study was observed one week postoperatively in one patient each from the 3D plate group and the miniplate group, which was statistically nonsignificant and correlated with studies performed by Jimson *et al.*, Prasad *et al.,* and Jain *et al.*[9,13,26]

CONCLUSION

There is a noticeable lack of studies showing lingual splay playing a role in the success of mandibular fracture treatment. The good old evaluation of occlusion has always been the go-to method to evaluate the success so far, so in this study we decided to take it up a notch by taking into consideration the less explored criteria, that is, lingual splaying, which is the main yet occult culprit behind flaring at the gonial angles and hence unesthetic facial widening. The final follow-up found that all of the modalities yielded good outcome in terms of reduction in splaying, occlusal discrepancies, and stability of fragments with no major complications. 3D plates were easy to maneuver and place in the anterior region compared with the other two, and their quadrangular shape is credited for the better stability of fragments. In terms of implant material, 3D plates, due to the lesser number of screws required than two miniplates and lag screw not requiring any additional component other than itself, have an advantage over conventional miniplates though this did not hamper the success of conventional miniplates. Lag screw placement was a significantly more time-conserving procedure compared with 3D plate and conventional miniplates though it required greater expertise in placement than the other two methods. It is safe to deduce that while one modality may have some advantages over another, all of them are equally good in terms of treatment outcome providing good stability, occlusion, and minimum or no complications.

With the availability of modern amenities such as CBCT and their rising relevance in our field, the evaluation and assessment of success of fracture treatment can be accomplished more beautifully by incorporating lingual splay as one of the primary parameters along with others. Although our study shows a good reduction in lingual splay in 60%, 80%, and 60% of the patients in the 3D plate group, the miniplate group, and the lag screw group, respectively, it has paved the way toward the same and we strongly recommend that more and more studies should be conducted in future with a larger sample size and longer study period including lingual splay as a vital parameter along with the other parameters to look out for in the field of Oral & Maxillofacial Trauma in India.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Sahu D, Chiang K, Jain S, Jain A. Fixation of mandibular angle fractures with a 3–dimensional strut plate–a prospective study. J Appl Dent Med Sci 2017;3:2.
2. Ponvel K, Panneerselvam E, Balasubramanian S, Kumar Raja VBK. Evaluation of labial versus labio-inferior lines of osteosynthesis using 3D miniplate for fractures of anterior mandible: A finite element analysis with a pilot clinical trial. Chin J Traumatol 2019;22:261-9.
3. Elhussein MS, Sharara AA, Ragab HR. A comparative study of cortical lag screws and miniplates for internal fixation of mandibular symphyseal region fractures. Alex Dent J 2017;42:1-6.
4. Schaaf H, Kaubruegge S, Streckbein P, Wilbrand JF, Kerkmann H, Howaldt HP. Comparison of miniplate versus lag-screw osteosynthesis for fractures of the mandibular angle. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;111:34-40.
5. Farwell DG. Management of symphyseal and parasymphyseal

mandibular fractures. Oper Tech Otolaryngol Head Neck Surg 2008;19:108-12.
6. Sauerbier S, Schon R, Otten JE, Schmelzeisen R, Gutwald R. The development of plate osteosynthesis for the treatment of fractures of the mandibular body a literature review. J Craniomaxillofac Surg 2008;36:251-9.
7. Farmand M. Three dimensional plate fixation of fractures and osteotomies: Facial plastic surgery. Clin North Am 1995;3:3956.
8. Farmand M, Dupoirieux L. The value of 3dimensional plates in maxillofacial surgery. Rev Stomatol Chir Maxillofac 1992;93:3537.
9. Prasad R, Thangavelu K, John R. The role of 3D plating system in mandibular fractures: A prospective study. J Pharm Bioallied Sci 2013;5(Suppl 1):S10-3.
10. Chaurasia A, Katheriya G. Prevalence of mandibular fracture in patients visiting a tertiary dental care hospital in North India. Natl J Maxillofac Surg 2018;9:123-8.
11. Ellis 3rd E, Tharanon W. Facial width problems associated with rigidfixation of mandibular fractures. J Oral Maxillofac Surg 1992;50:87–94.
12. Bhargava A, Subash P, Singh A. Novel method for mandibular fracture reduction using inter-fragmentary screw–report of a surgical technique. Br J Oral Maxillofac Surg 2020;58:e328-9.
13. Jimson S, Sankar A, Prasad R. Comparative study of stainless steel miniplate, three-dimensional plate and titanium three-dimensional plate for fixation of mandibular fractures. Int J Oral Maxillofac Surg 2009;38:502-3.
14. Siddiqui FI, Naphade MV, Naphade UM, Adwani DG, Shroff PR, Anwar SS. Management of anterior mandibular fractures using two different fixation methods. Arch Cran Oro Fac Sci 2016;4:4-9.
15. Mohammad O, Ashour E, Hassanein F. Evaluation of condylar position after ORIF of anterior mandibular fractures using 3 dimensional miniplate versus conventional miniplates: A randomized clinical trial. Egypt J Oral Maxillofac Surg 2021;12:1-3.
16. Hatem H, Abdel Monim G, El-Ghaffar A, Refahee S. Interfragmentary gap discrepancy after intraoral one-plate fixation in mandibular angle fracture. Egypt Dent J 2021;67:1909-14.
17. Mittal G, Aggrawal A, Garg R, Sharma S, Rathi A, Sharma V. A clinical prospective randomized comparative study on ostyeosynthesis of mandibular anterior fractures following open reduction using lag screws and miniplates. Natl J Maxillofac Surg 2017;8:110-6.
18. Tiwari M, Meshram V, Lambade P, Fernandes G. Titanium lag screw versus miniplate fixation in the treatment of anterior mandibular fractures. J Oral Maxillofac Surg 2019;77:1031-9.
19. Kaushik S, Ali I, Dubey M, Bajpai N. 2 mm conventional miniplates with three-dimensional strut plate in mandibular fractures. Ann Maxillofac Surg 2020;10:10-5.
20. Balakrishnan R, Ebenezer V. Three dimensional titanium mini plates in management of mandibular fractures. Biomed Pharmacol J 2015;7:241-6.
21. Sehgal S, Ramanujam L, Prasad K, Krishnappa R. Three-dimensional v/s standard titanium miniplate fixation in the management of mandibular fractures–A randomized clinical study. J Craniomaxillofac Surg 2014;42:1292-9.
22. Agnihotri A, Prabhu S, Thomas S. A comparative analysis of the efficacy of cortical screws as lag screws and miniplates for internal fixation of mandibular symphyseal region fractures: A randomized prospective study. Int J Oral Maxillofac Surg 2014;43:22-8.
23. Malhotra K, Sharma A, Giraddi G, Shahi AK. Versatility of titanium 3D plate in comparison with conventional titanium miniplate fixation for the management of mandibular fracture. J Maxillofac Oral Surg 2012;11:284-90.
24. Barde DH, Mudhol A, Ali FM, Madan RS, Kar S, Ustaad F. Efficacy of 3-dimensional plates over Champys miniplates in mandibular anterior fractures. J Int Oral Health 2014;6:20-6.
25. Jambhulkar M, Gupta S, Gupta H, Mohammad S. Study of comparison of bite force between conventional and 3D miniplate in mandibular fractures. Int J Sci Res 2017;6:153-8.
26. Jain MK, Sankar KC, Ramesh C, Bhatta R. Management of mandibular interforaminal fractures using 3 dimensional locking and standard titanium miniplates-A comparative preliminary report of 10 case. J Craniomaxillofac Surg 2012;40:475-8.